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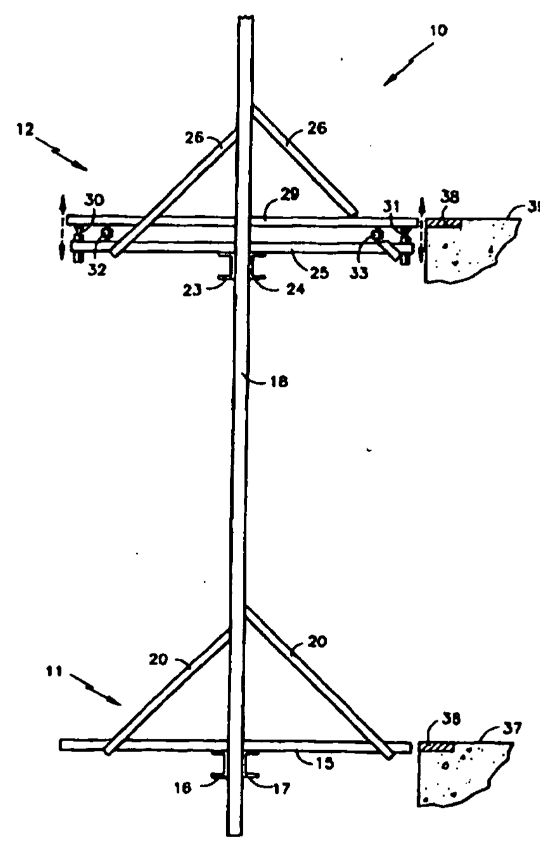
(54) Title: DOUBLE DECK ELEVATOR CAR WITH ADJUSTABLE FLOOR

(57) Abstract

The upper deck (12) of a double deck elevator (10) utilizes actuators (30, 31) to adjust the vertical distance between a moveable platform (29) and a fixed platform (15), thereby to accommodate spacing of landings (37, 39). Position sensors (32, 33) may be utilized in closed loop positional control (Fig. 2) of hydraulic, jack screw or linear actuators, or open loop position control (Fig. 3) may be used with stepper motors, one revolution clutches and the like. Adjustment may occur during car motion.



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Double Deck Elevator Car With Adjustable Floor

Technical Field

This invention relates to adjusting the relative distance between the two decks of a double deck elevator car to accommodate variations in interfloor spacing of a building.

Background Art

Double deck elevators require very precise and consistent floor separation distance to allow each of the decks to be leveled at a corresponding floor, simultaneously. The elevator car being positioned so as to have one deck level with the adjacent landing at the same time that the other deck were not level with its adjacent landing could precipitate injury to passengers, and code violations. On the other hand, leveling the car to allow passenger exchange at one floor followed by leveling the car for passenger exchange at the other floor would be too time consuming, and would offset the passenger flow advantage achieved with double deck elevators.

In new buildings, the consistent floor spacing requirement can be met with appropriate construction. However, maintaining the consistent floor spacing over time is an even greater challenge. The cost to accommodate double deck elevators in new construction is therefore greater than with single deck elevators.

The conversion of existing buildings from single deck elevator systems to double deck elevator systems is very difficult, due to the lack of consistency in interfloor spacing which is very common in buildings

not originally designed for double deck elevators.

Disclosure of Invention

Objects of the present invention include a capability to convert existing elevator installations from single deck elevators to double deck elevators, and double deck elevator systems which will facilitate installation in new buildings having a less stringent interfloor spacing specification.

According to the present invention, one deck of a double deck elevator car moves vertically relative to the car frame so as to adjust the interdeck spacing to suit the interfloor spacing of the pair of floor landings where service will next be provided. In accordance further with the invention, the elevator cab platform is moved vertically with respect to the car frame by means of actuators, which may be hydraulic, jack screws, or the like. In one embodiment, position sensors are utilized in a feedback control loop to assist in driving the platform to a correct position; in another embodiment, the platform is adjusted by driving stepper motors, one revolution devices or the like, a given number of times, in an open-loop fashion. In still further accord with the invention, deck adjustment is accomplished while the car is moving toward the next landing.

The invention provides versatility in being able to accommodate double deck elevators in buildings in which the floor spacing varies, including new construction made with less precision, construction of a variety which may have differential settling over a period of time, and retrofit installations in existing buildings.

The invention may be easily implemented utilizing only apparatus and technology available in the art, in the light of the teachings which follow hereinafter.

Other objects, features and advantages of the present invention will become more apparent in the light of the following detailed description of exemplary embodiments thereof, as illustrated in the accompanying drawing.

Brief Description of the Drawings

Fig. 1 is a simplified, stylized partial side elevation view of a double deck elevator car frame of the present invention, adjacent to a pair of floor landings.

Fig. 2 is a logic flow diagram of a floor correction routine employing positional feedback to adjust the variable platform of Fig. 1.

Fig. 3 is a logic flow diagram of a floor correction routine for adjusting the platform of Fig. 1 in an open loop fashion.

Best Mode for Carrying Out the Invention

Referring now to Fig. 1, an elevator car frame includes a lower deck 11 and an upper deck 12. The lower deck 11 includes a platform 15, for supporting a cab, resting on safety plank channels 16, 17 which are secured to a stile 18, there being another stile at the rear end (not shown). The platform 15 is stabilized to the stile 18 by means of braces 20. Similarly, the upper deck has safety plank channels 23, 24 supporting an auxiliary platform 25 (or frame) which is stabilized to the stile 18 by braces 26. In accordance with the invention, the upper elevator cab will rest on a

platform 29 which is moveable up and down relative to the platform 25 by means of actuators 30, 31. The relative position between the platforms 25, 29 may be sensed by suitable position sensors 32, 33 which may comprise linear variable differential transformers (LVDTs), or any other suitable position sensor. In one embodiment described with respect to Fig. 3, the position sensors 32, 33 need not be utilized.

In the embodiment of Fig. 1, the elevator car frame will be brought into a position, as shown, with the platform 15 of the lower deck 11 adjacent to a sill 36 of a landing 37, and the other platform 29 will be adjusted upwardly or downwardly by the actuators 30, 31, as shown by the arrows, so that it will be fairly level (within one or two millimeters) of the sill 38 of an adjacent landing 39. Of course, the invention may be implemented with an upper platform 29 which is stationary with respect to the stile 18 and a lower platform 15 which is moveable up and down with respect to the stile 18. In other words, it is immaterial whether the elevator is guided by the lower deck, and the upper deck is adjusted, or the elevator is guided by the upper deck and the lower deck is adjusted; both concepts fall within the invention.

One form of control for the actuators 30, 31 includes a subroutine which can be performed in a microprocessor already available as a car controller, or any other processor within the control system of the elevator, as desired. In the present embodiment, it is contemplated that the floor spacing of each pair of floors in the building (one and two, two and three, three and four, etc.) is measured and from that, the deviation of the upper floor in spacing from a nominal

spacing with respect to the next lower floor is stored as an increment, which, when related to a particular target floor (such as the landing 39), becomes a target floor increment (TRGT FLR INCR). The increments may all be above or below a nominal spacing, or the increments may be biased so that all increments are positive. This is irrelevant; in either event, the motion of the platform 29 may have to be upward or downward to position it correctly for the next target floor, depending upon the last place where the elevator stopped for which the position of the platform was adjusted. That is to say, it may move from having served passengers on the 19th and 20th floors to where it will serve passengers on the 11th and 12th floors. If the 11th and 12th floors are closer together than the 19th and 20th floors, then the platform will have to be moved down; if the 11th and 12th floors are farther apart than the 19th and 20th floors, then the platform 29 will have to be raised (in the embodiment of Fig. 1). Thus, the error (the direction of motion) may be positive or negative in any given case.

In Fig. 2, a floor correction routine utilizing positional feedback is shown. In this embodiment it is assumed that there are four actuators essentially at the four corners of the platform 29. These actuators may be referred to as 1-4, and include the actuators 30, 31 and two more actuators not shown. The position indicated by an adjacent position sensor may be related to the actuator by the same number: that is, position one (POS 1) will relate to actuator one (ACTR 1). In Fig. 2, if the elevator is not running, no floor correction is provided to the platform 29. Thus, after entering the routine through an entry point 40, a first

test 41 determines if the car is running or not. Assuming that the car is running, an affirmative result of test 41 reaches a test 42 to determine if the first actuator adjustment has been done or not. Initially, it will not have been done so a negative result of test 42 will reach a step 43 in which an error value (ERR) is determined as the difference between the position near actuator 1 minus the target floor increment, which comprises the position that is desired for actuator 1. Then a test 44 determines if the error is positive, and if so, it reaches a test 45 to determine if the error is within some small positive threshold (such as 1 or 2 millimeters). If the error is not sufficiently small, a negative result of test 45 will reach a step 46 to turn on actuator 1 in the positive direction. If the actuator is a jack screw, it will cause it to start turning in an appropriate direction to raise the platform 29; if the actuator is hydraulic, it will start the pump and apply pressure to the cylinder so as to raise the platform 29. In this embodiment, it is assumed that the routine of Fig. 2 can be reached several times a second so that it can periodically monitor the progress of adjusting the position of the platform 29 and eventually arrest the motion when it is in the appropriate place. Once the actuator is turned on, a test 50 is reached to see if actuator 2 has had its adjusting done or not. Initially it will not so a DO 2 subroutine 51, similar to the DO 1 subroutine 52 being described for actuator one, will be performed with respect to actuator two. Similarly, tests 53 and 54 will determine if actuator three and actuator four have been done, and until they have been, will cause a DO 3 subroutine 55 and a DO 4 subroutine 56 to be

performed.

If the error is determined in test 44 to be negative, a test 59 determines if the negative error is less than some small threshold such as minus one or two centimeters. If it is not, then a negative result of test 59 reaches a step 60 to turn on actuator one in a negative direction, thereby to cause the platform to be lowered in the vicinity of actuator one. In subsequent passes through the routine of Fig. 2, until correct positioning is achieved, either test 45 or test 59 will be negative, redundantly (but harmlessly) performing step 46 or step 50, respectively. Whenever the platform 29 has been positioned closely enough to the desired position by actuator one, either test 45 or test 59 will be affirmative reaching a pair of steps 61, 62 which will turn off actuator one and set a one done flag. In subsequent passes through the routine of Fig. 2, the result of test 42 is affirmative thereby bypassing the DO 1 subroutine which has just been described. However, each of the other subroutines 51, 54, 55 can be reached until the corresponding actuator has moved that corner of the platform 29 to a correct position as indicated by the corresponding position sensor. Once all of the actuators are in the correct position, while the car is still in the running condition, the routine of Fig. 2 will simply skip through the affirmative results of the tests 42, 50, 53 and 54, thereby reaching a return point 63 by which the processor reverts to other programming.

When the car reaches the landing, eventually it will come to rest with the brake engaged. In a next subsequent pass through the routine of Fig. 2, test 41 is negative reaching a test 66 to determine if the car

door (either one will do) is fully open. This is utilized just as a sequencing tool so that an affirmative result of test 66 will reach a plurality of steps 67-70 to reset all of the done flags so as to be ready for the next run of the elevator. Other sequence and control (instead of the run condition and door fully open condition) may be utilized if desired.

The invention may also be practiced without positional feedback, because the floor spacing does not change in any significant amount over long periods of time. In Fig. 3, a floor correction routine is reached through an entry point 73, and a first test 74 determines if the car is running; if so, a test 75 determines if the floor correction routine is done or not. In this case, since the actuators are being moved in an open loop fashion without feedback, all of them can be controlled in common. Therefore, only one done signal is required. Until the routine is done, a negative result of test 75 will reach a step 76 to set a last floor increment factor (LST FLR INCR) equal to a next floor increment (NXT FLR INCR). Then, the next floor increment is set equal to the target floor increment which indicates the deviation between the two floors 37, 39 at the landing where the elevator will next stop. Then, a count is set equal to the difference between the next floor increment and the last floor increment; this indicates the motion that is required to move the platform 29 from where it was last positioned to suit the interfloor spacing to where it should be to suit the interfloor spacing where the car will stop next. A test 79 determines if the count is positive, and if so, a step 82 causes an actuator to be pulsed in a clockwise direction; this embodiment

assumes that the actuator is a stepper motor or the actuator includes a motor with a one revolution clutch, which works through gearing to move the platform 29. In this embodiment, the increments are thereby expressed in terms of counts of a stepper motor or one revolution clutch, or the like. After causing one clockwise increment, the count is decremented in a step 83 and a test 84 determines if the count has now reached some low positive threshold. If not, other programming is reverted to through a return point 85.

If the platform is too low, test 79 will be negative reaching a pair of steps 88, 89 to cause the actuator to be moved counterclockwise and to increment the count (from some negative value toward zero). Then a test 90 will determine if the count is now smaller than some negative threshold value, and if not, other programming is reached through the return point 85. The pulsing of step 82 or step 88 will continue in successive passes through the routine of Fig. 3 until the corresponding count is reduced to the threshold.

Whenever the actuators have been pulsed sufficiently so as to move the platform 29 to the desired position, either the test 84 or the test 90 will have an affirmative result reaching a step 92 which sets the done flag utilized in test 75. Thereafter, as long as the elevator is running, each pass through the routine of Fig. 3 will simply follow affirmative results of tests 74 and 75 to reach the return point 85, the remainder of the routine being bypassed.

When the car comes to rest, a negative result of test 74 reaches a test 96 to determine if the doors are fully open. Initially, they will not be so a negative

result of test 96 reaches the return point 85. When the doors are fully open, a negative result of test 74 and an affirmative result of test 96 will reach a step 97 to reset the done flag. In subsequent passes through the routine of Fig. 3, a negative result of test 74 and an affirmative result of test 96 will redundantly, but harmlessly reset the done flag in step 97, and other programming is reached through the return point 85.

The invention may be implemented with analog control loops, in a well-known fashion in the light of the teachings hereinbefore. Other actuators may be used, to suit any particular application of the invention. The deck may be adjusted while the car is at rest; but, adjustment while the car is on a floor-to-floor run is believed to be preferred. The invention may be used on cars with more than two decks.

Thus, although the invention has been shown and described with respect to exemplary embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the invention.

I claim:

Claims

1. A multideck elevator for providing service to adjacent floors of a building, said elevator having a car frame, a first platform for an elevator cab immovably disposed on said car frame, and a second platform for an elevator cab movably disposed on said car frame so that the vertical spacing between said first platform and said second platform may be adjusted to substantially equal the vertical spacing between adjacent floors of said building at which service is to be provided.

2. A multideck elevator according to claim 1 wherein said second platform is moveable with respect to said car frame by means of actuators.

3. A multideck elevator according to claim 2 wherein said actuators comprise hydraulic actuators.

4. A multideck elevator according to claim 2 wherein said actuators comprise jack screws.

5. A multideck elevator according to claim 2 wherein said actuators comprise stepper motors.

6. A multideck elevator according to claim 2 wherein said actuators comprise motor driven one-revolution clutches.

7. A multideck elevator according to claim 1 further comprising:

position sensors for sensing the relative position of said second platform with respect to said car frame and providing position signals indicative thereof; and

motion control means for moving said elevator platform in response to said position signals.

8. A multideck elevator according to claim 1 further comprising:

position sensors for sensing the relative position of said second platform with respect to said car frame and providing position signals indicative thereof; and

motion control means for moving said elevator platform in response to said position signals while said car frame is moving toward floors at which service is to be provided.

9. A multideck elevator according to claim 1 wherein said second platform comprises the upper deck of said multideck elevator.

10. A method of operating a multideck elevator in a building which comprises adjusting the relative vertical distance between a lower deck of the elevator and an upper deck of the elevator so as to accommodate the interfloor distance between a pair of landings at an elevator service stop.

11. A method according to claim 10 wherein the relative vertical distance between the upper deck and lower deck of the elevator is adjusted as the elevator moves from one service stop to the next service stop.

12. A method of operating a multideck elevator in a building, comprising:

providing a multideck elevator having a car frame, a first deck for an elevator cab immovably disposed on said car frame, and a second deck for an elevator cab movably disposed on said car frame so that the vertical spacing between said first deck and said second deck may be adjusted; and

adjusting the relative vertical distance between one of said decks of the elevator and the other of said decks of the elevator so as to accommodate the interfloor distance between a pair of landings at an elevator service stop.

FIG. 1

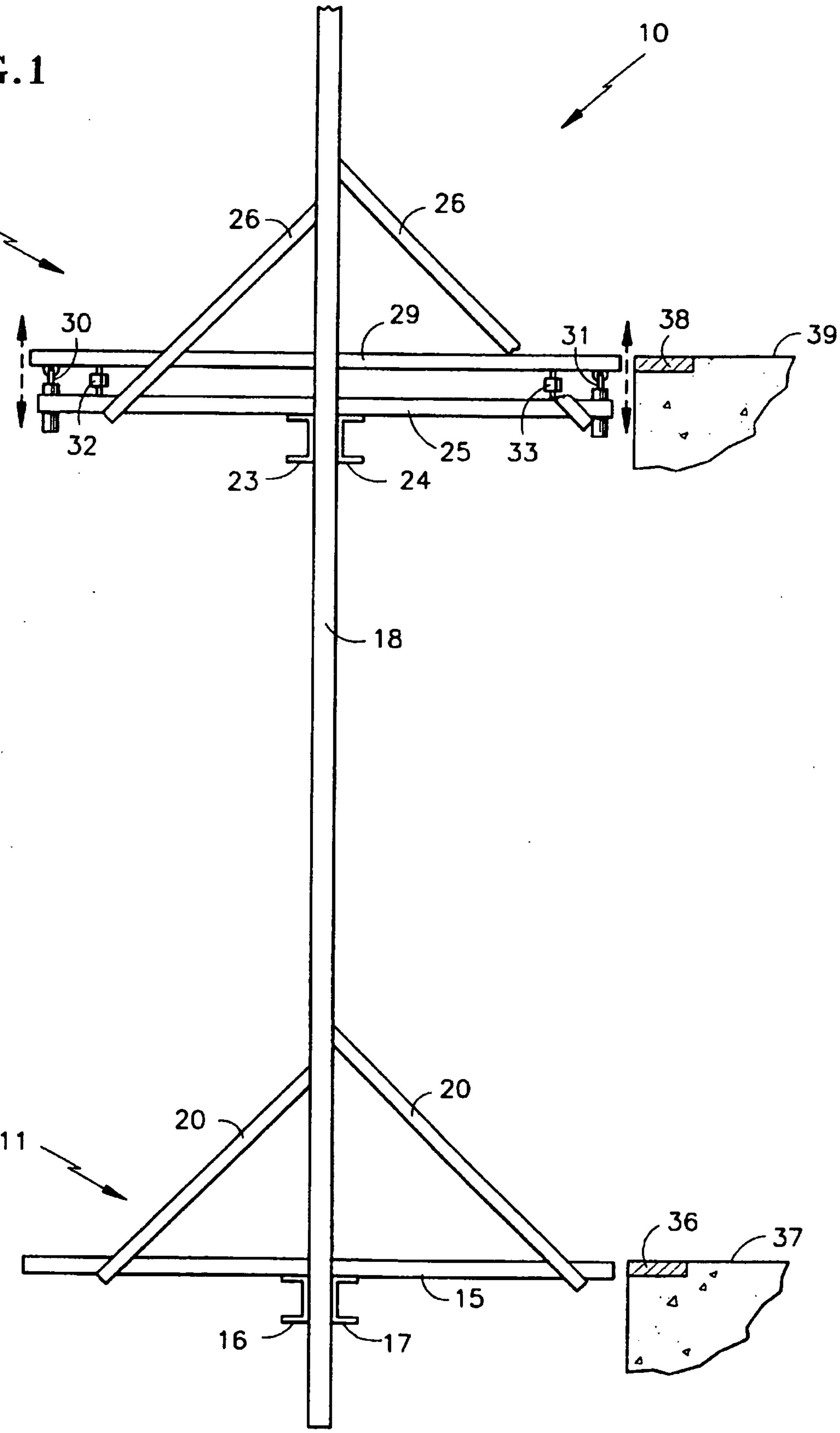
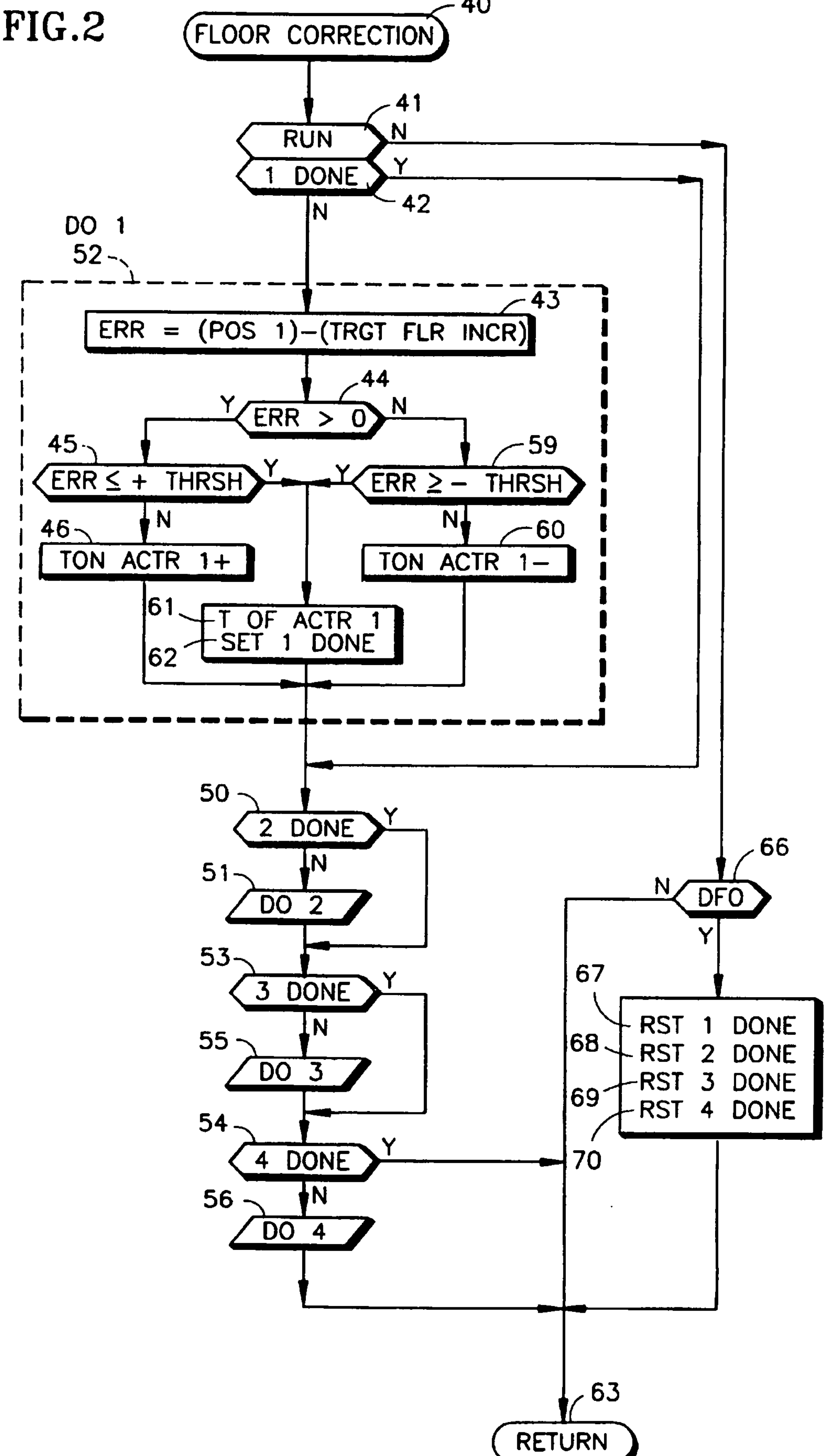


FIG.2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Y
42
N
DO 1
52
43
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44
Y
ERR > 0
N
45
ERR ≤ + THRSH
Y
Y
59
ERR ≥ - THRSH
N
46
TON ACTR 1+
N
60
TON ACTR 1-
61
T OF ACTR 1
62
SET 1 DONE
50
2 DONE
Y
51
N
DO 2
53
3 DONE
Y
55
N
DO 3
54
4 DONE
Y
56
N
DO 4
66
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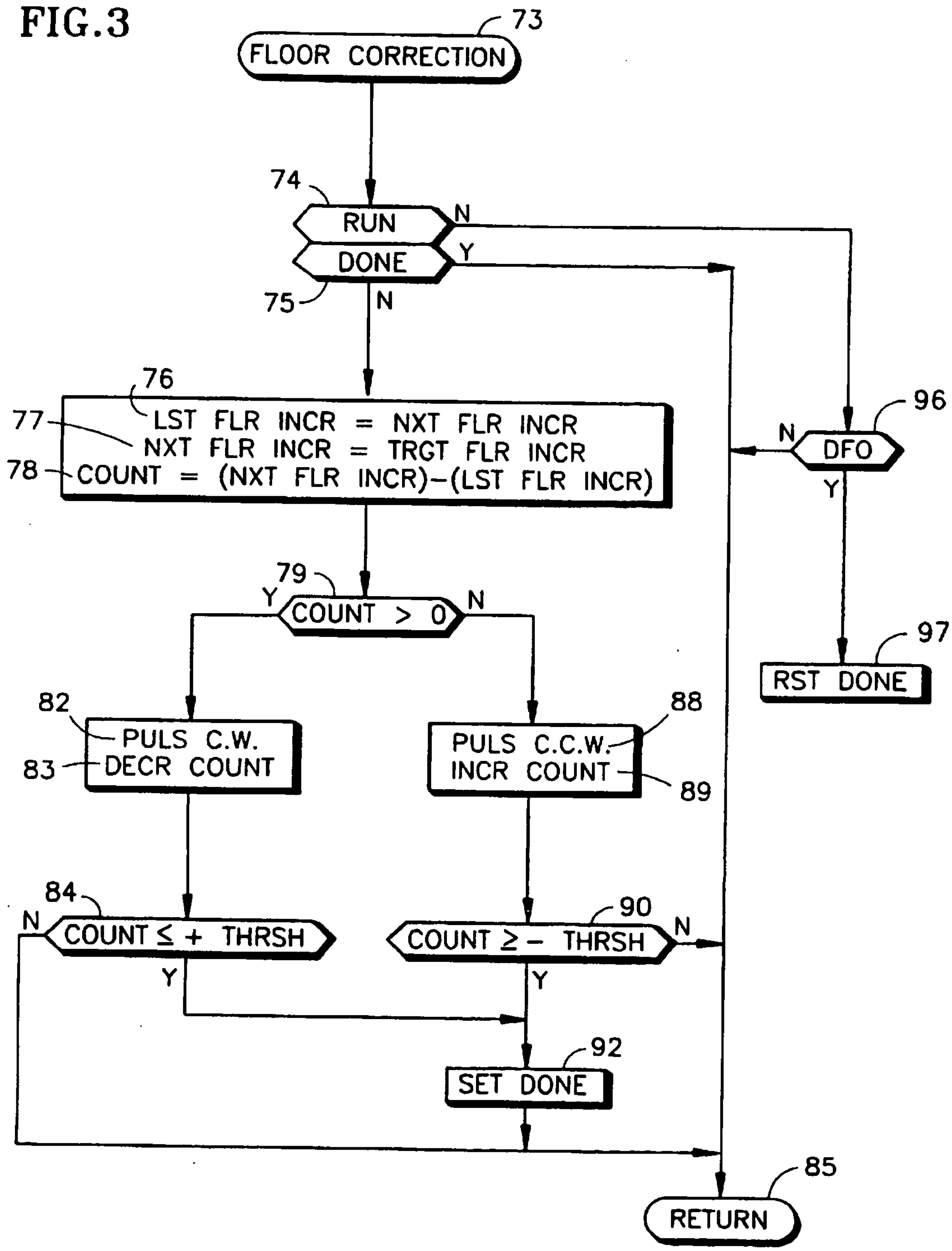
RST 2 DONE
RST 3 DONE
RST 4 DONE
63
RETURN

FIG.3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DONE
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75
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77
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NXT FLR INCR = TRGT FLR INCR
COUNT = (NXT FLR INCR)−(LST FLR INCR)
96
N
DFO
Y
79
Y
COUNT > 0
N
97
RST DONE
82
PULS C.W.
83
DECR COUNT
88
PULS C.C.W.
INCR COUNT
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84
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Y
90
COUNT ≥ − THRSH
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Y
92
SET DONE
85
RETURN

INTERNATIONAL SEARCH REPORT

Intern: al Application No
PCT/US 97/13906

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B66B1/42 B66B9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B66B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 750 849 A (BERKOVITZ H) 7 August 1973 see column 2, line 32 - line 42 see column 5, line 55 - column 6, line 44 see figure 2 ---	1,10,12
A	FR 1 064 070 A (S.A.H.E) 11 May 1954 see claim 1; figures -----	1,10,12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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2

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. al Application No
PCT/US 97/13906

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3750849 A	07-08-73	US 3651893 A	28-03-72
FR 1064070 A	11-05-54	NONE	